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Development of Eye Gaze and Point Following

And its Relation to Word Learning

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Development of Eye Gaze and Point Following

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Dedication

This thesis is dedicated to my family, friends, and mentors who have encouraged and helped me through this process.

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Abstract

Development of Eye Gaze and Point Following

And its Relation to Word Learning

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The University of Texas at Austin, 2018

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Abstract: Socio-pragmatic cues are essential for supporting early word learning. Children use social cues, such as eye gaze and pointing to isolate and learn about referents in their environment. To what extent might individual variability in children's ability to capitalize on these word-learning strategies relate to the well-documented differences in vocabulary development associated with socioeconomic status? To answer this question, we asked 170 2.5- to 3.5-year-olds to identify the referents of novel words based on cues from either the experimenter's gaze alone, or that gaze in combination with a pointing gesture. We found that socioeconomic status correlates with the use of eye gaze and point following for learning new words. Further, children from higher socioeconomic status households more reliably used these cues. The results of this study could have implications for our understanding of the differences in vocabulary development, as well as on how to best intervene in children's early word-learning skills.

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1. BACKGROUND

The rapid growth of a child's early vocabulary is a well documented phenomenon. For the sake of perspective, a 12-month-old child produces approximately two new words per week (Carey, 1978). By 19 months of age, that rate increases substantially to roughly nine new words per day (Bloom, 1973; Templin, 1957). A long tradition of empirical research has explored how this seemingly inconceivable task is accomplished and has led to the identification of a number of potential underlying mechanisms. One such mechanism that has received particular attention in the literature rests on children's early emerging ability to track the intentions of others. Specifically, the ability to identify an intended referent of a novel label based on joint attention cues like eye gaze and pointing appears to be a pivotal skill in the process of vocabulary acquisition (Baldwin & Tomasello, 1998; Hollich et al., 2000). It is widely held that this capacity emerges in the second year of life (Baldwin, 1991; Hennon, 2000; Pruden, Hirsh-Pasek, Golinkoff, & Hennon, 2006). However, there is some evidence suggesting that these skills continue to develop well into the third year (Baldwin, 1993; Booth, MacGregor, & Rohlfing, 2008; Brand, 2000; Woodward, 2004). There is reason to consider whether even this lengthened trajectory accurately reflects the reality for all children. As is the case with much developmental research, the participants in these foundational studies were recruited primarily from white middle to upper-class households. Given the established relationship between socioeconomic (SES) related experiences and vocabulary development, it is entirely feasible that the underlying word learning skills supporting vocabulary acquisition might emerge over an even more protracted developmental time frame for children facing socioeconomic disadvantage. In this

study, we will explore this possibility by examining relationships between children's age, socioeconomic status, and their skill at using eye gaze and pointing to learn novel words.

1.1. EARLY LINGUISTIC EXPERIENCE AND VOCABULARY GROWTH

It is well established that disparities among children in their early language experience are related to aspects of vocabulary and language growth (Hoff, 2013; Pan, Rowe, Singer, & Snow, 2005; Rowe, 2012; Song, Spier, & Tamis, 2014). Indeed, children from low-SES households develop their vocabularies at slower rates than their peers from high-SES households (Arriaga, Fenson, Cronan, & Pethick, 1998; Dollaghan et al., 1999; Feldman et al., 2000; Champion, Hyter, McCabe, & Bland-Stewart, 2003; Hart & Risley, 1995). In Hart and Risley's (1995) oft-cited longitudinal comparison of high-SES (professionals), mid-SES (working class), and low-SES (on welfare) families with a child under two years of age, it was found that, over the course of one week, children from high-SES households heard 215,000 words on average, children of mid-SES parents heard 125,000 words, and children of low-SES parents heard 62,000 words. As a result, by the age of three years, the authors concluded that children from families of low-SES households were estimated to have heard approximately 30 million fewer words than their more affluent peers (Hart & Risley, 1995). A similar study in which monthly, daylong recordings of 2-month to 48-month old infants' natural language environments were recorded over a span of approximately 6–38 months, the word gap was estimated to be closer to four-million-words (Gilkerson, et al., 2015). Despite inconsistencies in the reported breadth of the disparity, research supports the notion that there are differences in input when comparing low SES to that of higher SES families.

This disparity in the number of words a child hears has been found to be associated with the size of their vocabulary. In fact, children from socioeconomically disadvantaged backgrounds enter preschool with less than half the oral vocabulary as their more advantaged peers (Hart & Risley, 1995). Hirsh-Pasek, et. al. (2015) found that the quality of parents' language input (i.e., symbol-infused joint engagement, routines and rituals, fluent and connected communication) provided to their two-year-old children accounted for 27 percent of the variation in children's language skills one year later. Notably, these early emerging gaps continue to grow over time and, by fifth grade, children from high-SES households know, on average, 4,000 more words than their low-SES peers (Biemiller & Slonim, 2001). The students with smaller vocabularies may go on to experience greater difficulty with both reading comprehension (Chall, Jacobs, & Baldwin, 1990) and future content learning in school (Biemiller, 2001; Chall et al., 1990). These differences in the number of words known is commonly referred to as the 'vocabulary gap.'

Importantly, the noted language disparities between children from varying socioeconomic statuses goes beyond merely the size of their vocabulary. In a study comparing the language skills of low-income toddlers and those of middle-income households, the scores for the low-income group were strikingly lower on the three key indices evaluated: size of expressive vocabulary, age of appearance of word combinations, and complexity of utterances (Arriaga, Fenson, Cronan, & Pethick, 1998). Further, Dollaghan et al. (1999) found scores on norm-referenced and conversational language measures to be positively correlated with maternal education levels.

While the specific mechanisms underlying the vocabulary gap have yet to be definitively established, evidence suggests that a variety of factors might contribute, including differences in

(a) language-specific learning experiences (Hoff & Naigles, 2002; Hoff-Ginsberg, 1998); (b) broader aspects of the home environment (Linver et al., 2002); and (c) biologically or health based factors. Of these, the early linguistic input an infant receives (including the amount, variability, complexity, and quality of child directed speech) has most consistently been identified as a key element influencing the rate at which vocabulary is acquired (e.g., Hart & Risley, 1995a; Hoff, 2006a; Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010).

1.2. JOINT ATTENTION AND ITS RELATION TO WORD LEARNING

One aspect of early linguistic input that has received particular attention is joint attention. Engaging in joint attention involves sharing a common focus on something (i.e., an object, event, concept, person, etc.) with someone else. These interactions are typically mediated by communicative gestures (e.g., pointing) and/or eye-gaze (visually focusing on the attentional target). The ability of infants to engage in joint attention is considered critical to their social, emotional, and cognitive development, and of particular interest here, is associated with their capacity to acquire language (Adamson & McArthur, 1995; Bruner, 1975, 1977; Bates, 1979; Bakeman & Adamson, 1984; Moore & Corkum, 1994; Tomasello, 1988, 1995). In fact, during a 15 minute play session, Hirsh-Pasek et al. (2015) found that the quality of a parent-child joint attention interaction was more predictive of a child's expressive language one year later than either the number of words a mother used (quantity) or a rating of sensitive parenting. Further, the quality of these interactions varied depending on maternal education, with higher SES mothers engaging, on average, in higher quality joint attention interactions than low SES counterparts (Hirsh-Pasek et al., 2015).

Sensitivity to joint attentional cues (like eye gaze and pointing) is thought to be particularly important in isolating the intended referents of new words from the host of alternatives available in any given labeling episode. Indeed, research has shown that a caregiver's tendency to follow a child's line of regard in a joint attention episode is related to lexical development (Dunham & Dunham, 1993; Masur, 1981; Tomasello, 1988; Tomasello & Farrar, 1986; Tomasello & Todd, 1983). Further, individual differences in the ability of 6- to 18-month-old infants to respond to joint attention has been shown to be a reliable predictor of language ability at 24 to 36 months (Markus, Mundy, Morales, Delgado, & Yale, 2000; Morales, Mundy, & Rojas, 1998; Mundy & Gomes, 1998; Mundy, Kasari, Sigman, & Ruskin, 1995).

Although compelling, these studies do not fully specify the potential mechanisms by which joint attention might support language development. It is possible that both direct and indirect effects are involved. As typically conceptualized, joint attention episodes directly facilitate acquisition of words by helping children to discover the intended referents of new words. That is, in hearing a label during a joint attention episode with the speaker, a child is better able to figure out the intention of the speaker in a controlled and focused context. However, at the same time, these episodes might indirectly promote the acquisition of vocabulary by bolstering word-learning skills. Each time a child successfully engages in joint attention with a responsive adult, they have an opportunity to reaffirm the value of attending to a speaker's eyes and hands. And when these interactions occur in the context of labeling, the child learns the importance of attending to these actions specifically as cues to the meaning of words.

It is likely that experience with joint attention also impacts a child's ability to abstract other cues to word meaning that go beyond simply following a caregiver's gaze and/or point to a

specific referent. For example, joint attention episodes might indirectly provide a platform for acquiring the whole object and mutual exclusivity assumptions, both of which are thought to further contribute to vocabulary acquisition. According to the whole object principle, children will attach a novel label to a whole object as opposed to a salient part or property thereof (Markman & Wachtel, 1988). For example, using the whole object principle, if a child is shown an object and given the label "truck," the child will assume "truck" refers to the entire object instead of the tires, doors, color or other parts (Hansen, 2009). The mutual exclusivity assumption refers to young children's tendency to map new words onto referents for which they do not already know a name (Golinkoff, Hirsh-Pasek, Bailey, & Wengner, 1992; Markman, Wasow, & Hansen, 2003; Mervis & Bertrand, 1993). As such, the principle permits children to rule out potential referents in a naming context that are already represented in their vocabulary.

Research suggests that the application of both the whole object principle and the mutual exclusivity assumption hinges on socio-pragmatic cues (like those offered during joint attention episodes) from caregivers (Diesendruck & Markson, 2001; Malle, Moses, & Baldwin, 2001; Saylor, Sabbagh, & Baldwin, 2002, Callanan & Sabbagh, 2004). Broadly defined, socio-pragmatic cues include "the social perceptions underlying participants' interpretation and performance of communicative action" (Kasper & Rose, 2017). So, during joint attention episodes, socio-pragmatic cues could include a communication partner's use of gestures, eye gaze, facial expressions, or a myriad of other contextually dependent signals of the communicative intent.

Indeed, when engaged in joint attention episodes in which they are intentionally labeling the whole target object, a parent may use a circular/sweeping motion while pointing, to indicate

that the label is referencing the entire object as opposed to a part of the object. It logically follows that the more experience a child has in contexts that clearly pick out a referent, the more likely they are to notice that the 'correct referent' of a novel word is a novel thing they do not have a name for. In a study conducted by Callanan and Sabbagh (2004), 12- to 24-month old children and their parents were recorded in free-play, storytelling, and categorization contexts. Parents showed an overall preference to give their children only one label for an object rather than two, thereby aligning their input with the mutual exclusivity assumption. Further, when parents provided only one label, it was in reference to the whole object, thus aligning with the whole object assumption. When parents did offer two labels, they often gave clarifying information when the child incorrectly labeled an object (e.g., It looks like a *train*, but it's really a *tractor*) or provided the name for the whole object first before providing the name of the part (e.g., This is a *giraffe* with a long *neck*; Callanan & Sabbagh, 2004).

In summary, theory and research suggest that experience with joint attention is important for the development of both word learning strategies and principles (i.e., eye gaze and point following, mutual exclusivity, etc.) and vocabulary itself. Because in this project we are particularly interested in the development of children's use of eye gaze and pointing in learning new words, we next consider evidence regarding the developmental time-course over which these skills emerge, using the Emergentist Coalition Model (ECM) of word learning as a framework.

1.3. EYE GAZE AND POINT FOLLOWING DEVELOPMENT

According to the Emergentist Coalition Model (ECM) of word learning, the development of both eye gaze and point following becomes increasingly tied to intention and communication

when practiced in joint attention routines. This model rests on three basic tenets: (1) that children utilize multiple attentional/perceptual and linguistic cues that are available to them in the language-learning situation; (2) that children's ability to use these cues changes over time, as does their relative weight; and (3) that children develop word learning principles of language over time (Hollich et al., 2000). At any given point in time, multiple environmental inputs are available to children. The differential interpretation and weighing of the inputs is closely related to which principles of word learning have already been acquired or are emerging for that individual. As such, the lens through which environmental input is understood and interpreted is related to where an individual falls on this developmental progression. Vocabulary acquisition is considered the emergent product of multiple factors including global attentional mechanisms, cognitive constraints, and social pragmatic components (Hollich et al., 2000).

The tenets of ECM can be used to explain the complexities of early vocabulary acquisition, and of specific relevance here, the origins of a child's sensitivity to eye gaze and point following during joint attention episodes. As children progress through the language learning process and are given more opportunities to "practice" learning new words through episodes of joint attention, immature principles (e.g., assigning a label to the most interesting thing in a given context) give way to more mature principles (e.g., following a speaker's eye gaze to identify the referent; Pruden et al., 2006).

Infants as young as 6 months of age follow an adult's direction of gaze in experimentally controlled circumstances (Morales, Mundy, & Rojas, 1998). The transition from merely following the direction of an adult's gaze to successfully using that social cue to infer the referent of novel words, however, does not emerge until the second year of life (e.g., Baldwin, 1991;

Hennon, 2000; Pruden, Hirsh-Pasek, Golinkoff & Hennon, 2006). This ability appears to depend on an infant's sensitivity to the intentions of the speaker. Notably, in a novel word learning task, Baldwin (1993) demonstrated that 18-, but not 14-, month-old infants were sensitive to eye-gaze, even when it required that they stop attending to their current focus. As expected, in conditions in which experimenters looked at and labeled objects to which the infant was already attending, infants consistently mapped the novel name onto the accurate referent. However, when the infant was not already focusing on the object that the experimenter labeled, 18-month-old infants, but not 14-month-olds, successfully mapped the words to the intended referent.

Importantly, other evidence suggests that development of these eye-tracking skills might be more protracted than these early studies suggest, with below ceiling performance evident for at least some children into the third year (Brand, 2000; Woodward, 2004; Booth, MacGregor, & Rohlfing, 2008). In her work examining children's use of multiple cues in word learning contexts, Brand (2000) found that 12- and 18-month-old infants were unable to identify a target object when it changed sides of the table during test trials while 24-month-olds were only partially resistant to this manipulation. All three age groups were proficient in following social eye gaze in more controlled conditions, but adding in this simple spatial manipulation led to a decrease in each group's performance. Twenty-four-month-olds showed below ceiling performance with, but an emerging ability to attend to, the accurate referent. Likewise, while Booth et al. (2008) found evidence of a positive effect of gazing, pointing, touching, and manipulating on the ability of 2.5-year-old infants to isolate the intended referents of novel words, toddlers displayed an average success rate of only 50% across trials involving eye gaze cues alone.

A skill closely related to eye gaze is a child's ability to use, and appropriately respond to, a referential point, which involves the extension of the hand and the index finger toward a specific object or event of interest (Butterworth, Franco, McKenzie, Graupner, & Todd, 2002; Butterworth & Morissette, 1996; Leavens, Hopkins, & Thomas, 2004). The pointing gesture is arguably one of the most important ways for an infant to communicate with the world and is considered a strong predictor for later vocabulary (Iverson & Goldin-Meadow, 2005; Özçaliskan & Goldin-Meadow, 2006).

Between the end of the first and the beginning of the second year, infants begin to produce and to understand the pointing gesture in their interaction with others. There is noted variation in the age of onset for the production of this gesture. The ability to produce the point gesture has been shown to emerge between 7- and 15- months, with a mean age around 11–12 months (Camaioni, Perucchini, Bellagamba, & Colonnesi, 2004; Carpenter, Nagell, & Tomasello, 1998). Use of the pointing gesture continues to improve in the second year of life in concert with the onset of language (Carpenter et al., 1998; Dobrich & Scarborough, 1984).

As children become more adept at producing the pointing gesture in joint attention episodes, they begin to understand the communicative impact it has with others and will begin to appropriately respond to the point of others. The developmental trajectory of an infant's response to a pointing gesture when a communication partner uses it is varied. By 10-months-of-age, most infants will check the adult's gaze after the point to make sure it was perceived and at 16 months, infants will look at the adult before they point (Franco & Butterworth, 1996). By 17 months of age, pointing begins to influence an infant's attention in labeling episodes in a more pronounced way. Specifically, for 17- but not for 10-month-olds, looking time toward an object increased

when a label was accompanied with a pointing gesture (Baldwin & Markman, 1989). As noted above, this increased attention likely develops at different rates for individual children. In fact, Booth et al. (2008) reported well below ceiling performance and high variability in 2.5-year-old infants' ability to appropriately identify intended referents based off an adult's gaze or an adult's gaze coupled with a point.

Interestingly, this age range marks a broader developmental change in regards to children's reliance on eye gaze vs. pointing for learning new words. In a particularly revealing study, Paulus & Fikkert (2014) employed an eye-tracking paradigm while participants were shown a movie featuring an actor who repeatedly presented a novel word and simultaneously gazed at one of two objects but pointed at the other. Results revealed that 14-month-old infants paid more attention to a model's eye gaze when determining the intended referent of novel words, while 24-month-old infants and adults relied more on pointing cues. These results provide evidence for developmental change in how infants differentially weigh eye-gaze and pointing to map novel words onto referents. Specifically, as an infant gains more experience in determining a communication partner's intent, the pointing cue begins to take precedence over eye gaze. This phenomenon could perhaps be explained by the fact that, as infants gain additional experience with more complex labeling episodes, pointing emerges as a reliable indicator of the intention to establish joint attention. That is, people rarely point at something unless deliberately attempting to gain someone else's attention, but will often look at things without the intention to draw others' attention to it.

While empirical evidence has provided a detailed outline of the general developmental trajectory of infants' sensitivity to eye gaze and point following, less information has emerged in

answering the question of why substantial individual variability in using these skills for word learning exists and what that variability might mean for the acquisition of vocabulary. One possibility, consistent with the Emergentist Coalition Model of word learning, is that early experiences with joint attention shape these skills. Evidence suggests that households vary in ways that might well be relevant to the development of infants' sensitivity to eye gaze and pointing. For example, parents vary considerably in their sensitivity and responsiveness to their children's attentional cues, as well as the degree to which they utilize communicative gestures (e.g., Hart & Risley, 1995b; Hoff-Ginsberg, 1998; Raver & Leadbeater, 1995; Rowe & Goldin-Meadow, 2009). Evidence further suggests that these parenting behaviors relate to other child language outcomes (e.g., Pan, Rowe, Singer, & Snow, 2005; Tomasello & Farrar, 1986). As such, early communicative experiences associated with socioeconomic disadvantage might influence the development of word learning skills like attending to joint attention cues. Indeed, these skills might well mediate the already well-established relationship between indicators of SES and vocabulary.

1.4. CURRENT STUDY

The current study examines individual differences in children's ability to accurately interpret an adult's eye gaze and point. Specifically, we will examine relationships between children's age, socioeconomic status, performance on a standardized vocabulary test, and their skill at using eye gaze and pointing to learn novel words. We predict that, for high-SES children, the age at which the eye gaze and point following skills develop will be earlier than children from low-SES backgrounds. Specifically, the following questions will be explored: (1) Does

socioeconomic status correlate with the use of eye gaze and point following for learning new words? and (2) Is higher socioeconomic status associated with more reliable use of these cues?

2. METHODS

2.1. PARTICIPANTS

In addition to contacting participants who were already enrolled in the Children's Research Center's database, recruitment included attending parent meetings, as well as passing out flyers and bookmarks in preschools, community centers, and other public places. One hundred and seventy 2.5- to 3.5-year old participants from the Austin, Texas area participated in the study (M = 2.97 years, SD = 0.03 years, Range = 2.51-3.57 years). To ensure full understanding of the tasks, exclusion criteria included hearing impairment, language impairment or delay, and child exposure to more than 50% non-English language in the home. Our sample was culturally and ethnically diverse, with 54% being Caucasian, 32% Hispanic, 9% Black/ African American, 3% Asian/Pacific Islander, and 1% American Indian; no information on race/ ethnicity was available for 2 participants. In regards to maternal education, 24 % of mothers reported at most completion of a high school degree, 16 % completed an associates or technical degree, 32% had a four-year bachelor's degree, and 28 % held a master's degree or higher.

2.2. DESIGN OVERVIEW

The current study was part of a larger longitudinal study specifying the nature of the vocabulary gap with respect to word learning skills. The measures utilized in this particular study included a standardized test of children's vocabulary, an experimental test of eye gaze and point following skills, and a measure of the child's executive functioning skills. Parents or guardians also participated in two short demographic and home environment interviews. Children were

tested in a quiet room in the Little Learners Laboratory (within the Children's Research Center) on the UT Austin campus. Some children were also tested at off-site preschools.

2.3. ASSESSMENT OF SOCIOECONOMIC STATUS

In order to gain insight into the child's home environment and background, face-to-face or phone interviews with the child's guardian were conducted across two occasions. The questions in this interview were excerpted from those used by Angel, Burton, Chase-Lansdale, Cherlin, Moffitt & Wilson (1999) and included the following sections: Race/Ethnicity, English Proficiency and Language, Education and Occupation, and Home Environment. Because no clear consensus exists regarding which factors best and most accurately index socioeconomic status, we focused on maternal education, which has been shown to reliably correlate with child outcomes (Ensminger & Fothergill, 2003). Further, outside of extreme poverty, maternal education has been identified as relating most strongly to parenting measures (i.e., quality of maternal speech, joint attention episode engagement; Bornstein, Hahn, Suwalsky, & Haynes, 2003; Hoff et al., 2002).

2.4. ASSESSMENT OF VOCABULARY

The Peabody Picture Vocabulary Test – Fourth Edition (PPVT-4) form A was used to assess participants' receptive vocabulary (Dunn & Dunn, 2007). This standardized assessment is designed for use with children as young as 2.5 years of age and takes approximately 10 to 30 minutes to administer. On each trial, a participant is asked to identify a picture from a set of four, which best represents the spoken word given by the examiner. The PPVT-4 was extensively

evaluated to minimize item bias, and was normed on a large and diverse sample (Dunn & Dunn, 2007; Williams, 2007).

2.5. ASSESSMENT OF WORD LEARNING

We assessed children's sensitivity to eye gaze and point following as a cue to reference using a procedure modeled after Booth, MacGregor, and Rohlfing (2008). At the start of each of eight trials, three novel objects were lined up on a table out of the child's reach. To minimize any potential impact of the basic processing skills that might affect children's performance, we intentionally used simple and slow speech, kept the task short and engaging, required the encoding and retention of as little information as possible over brief periods of time, and tested in minimally distracting settings. Further, in order to minimize a need for children to inhibit attention towards objects of particular interest, we drew the child's attention to a neutral location at the experimenter's chest with a squeaker toy at the start of each trial. For the first 4 trials, while looking intently at one of the objects, the experimenter labelled the intended referent 3 times (e.g., 'Look, it's a koob!'). She then gathered all three objects, dropped them into a clear rectangular container, and asked the child for the target (i.e., 'Where is the koob?'). The same procedure was followed for the last 4 trials, except that the experimenter pointed to the target, in addition to looking at it while labeling. This task took approximately 10-15 minutes to administer.

2.6. ASSESSMENT OF ATTENTION AND EXECUTIVE FUNCTION

In order to assess the potential influence of factors related to attention on participants' performance, we used a five point rating scale to rate each child's level of engagement during the

word learning task. The rating was independently determined by a coder while watching a digital video recording of the participant engaging in the task. A score of less than 3 indicated insufficient engagement for meaningful interpretation of performance and was grounds for discarding the data for that participant. Nineteen children were excluded for this reason.

We were also interested in the potential effects of executive functioning abilities on task performance. Executive function refers to "high-level cognitive processes required to plan and direct activities, including task initiation and follow-through, working memory, sustained attention, performance monitoring, inhibition of impulses, and goal-directed behavior (Dawson & Guare, 2010). Importantly, a strong concurrent relationship between language and executive functioning has been identified in previous work (e.g., Gooch, et al., 2015). In order to evaluate whether executive functioning skills might contribute to performance on our word learning task, we had participants complete the Minnesota Executive Function Scale (MEFS) to assess their executive function abilities. The MEFS consists of children playing a digital game on an iPad in which they sort picture cards into boxes. The measure takes approximately 5 minutes to complete and provides information about a child's skills related to their executive functioning abilities.

2.7. CODING AND RELIABILITY

Video recordings of the task were used to code children's choice responses during the word learning task following the session. Coders recorded children's responses to each trial. A percentage correct was calculated and used during analysis (e.g. if a child accurately chose the target in 5 out of 8 trials, they would receive a score of 62.50). All standardized tests were scored according to their published instructions and were checked by a second scorer to ensure

accuracy. Both the MEFS assessment and PPVT-4 provide a standardized score based on the child's performance and age. Finally, a global rating of the child's attention level during each task on a 5-point scale, fidelity of implementation, level of engagement, and any other comments were also noted for each task.

3. RESULTS

Table 1 outlines descriptive statistics including means and standard deviations for primary study variables. Performance on the word learning task was well below ceiling (i.e. score = 100) and well above floor (i.e. score = 0) with high variability (M = 63.34, SD = 22.84). Further, three children were excluded for failure to complete the procedure, ten for being given a score of less than 3 on the attention rating scale, and two due to experimenter errors. Because the word learning task took place as part of a larger study focused on vocabulary development, 15 children from our larger sample had not completed the session with the word learning task at the time of our analysis.

The children's performance on the PPVT-4 was within the expected normal distribution for this age range. Performance on the PPVT-4 was well below ceiling (i.e. score = 99.9) and well above floor (i.e. score = 0) with high variability (M = 61.81, SD = 29.75). From our sample, four children's PPVT scores were excluded from our analysis due to being rated with attention scores less than 3, 7 seven due to not having completed the session with the PPVT-4 assessment, and two due to experiment error.

Finally, performance on the MEFS also fell within the expected normal distribution for this age range. Performance on the MEFS assessment was below ceiling (i.e. score = 99.9) and well above floor (i.e. score = 0) with high variability (M = 51.21, SD = 23.07). At the time of our analysis, 15 children had not completed the session in which MEFS was administered. Further, nine children were excluded due to receiving attention scores of less than 3, and six due to technological malfunctions.

Table 1. Descriptive statistics for primary study variables.

Statistic	N	M	SD	Min	Max
Child Age	170	2.97	0.30	2.51	3.57
Maternal Education (Years in School)	170	15.73	2.98	7.0	23.0
PPVT-4	157	61.81	29.75	1	99.9
Word Learning Task (All Trials)	140	63.34	22.84	12.50	100
Word Learning Task (First 4 Trials w/Gaze Only)	140	57.32	30.80	0	100
Word Learning Task (Second 4 Trials w/Gaze +Point)	140	68.57	28.19	0	100
MEFS	140	51.21	23.07	4	97

Bivariate correlations were computed to examine associations between key variables (see Table 2). In order to address our primary research question, we were particularly interested in the bivariate correlation between performance on the word learning task and socioeconomic status, as measured by maternal education. A positive association was observed when all eight trials of the word learning task were considered in the analysis, $r(138) = 0.17$, $p = 0.04$. See Figure 1 for a scatterplot of the relevant data. However, when examined separately, this correlation only held

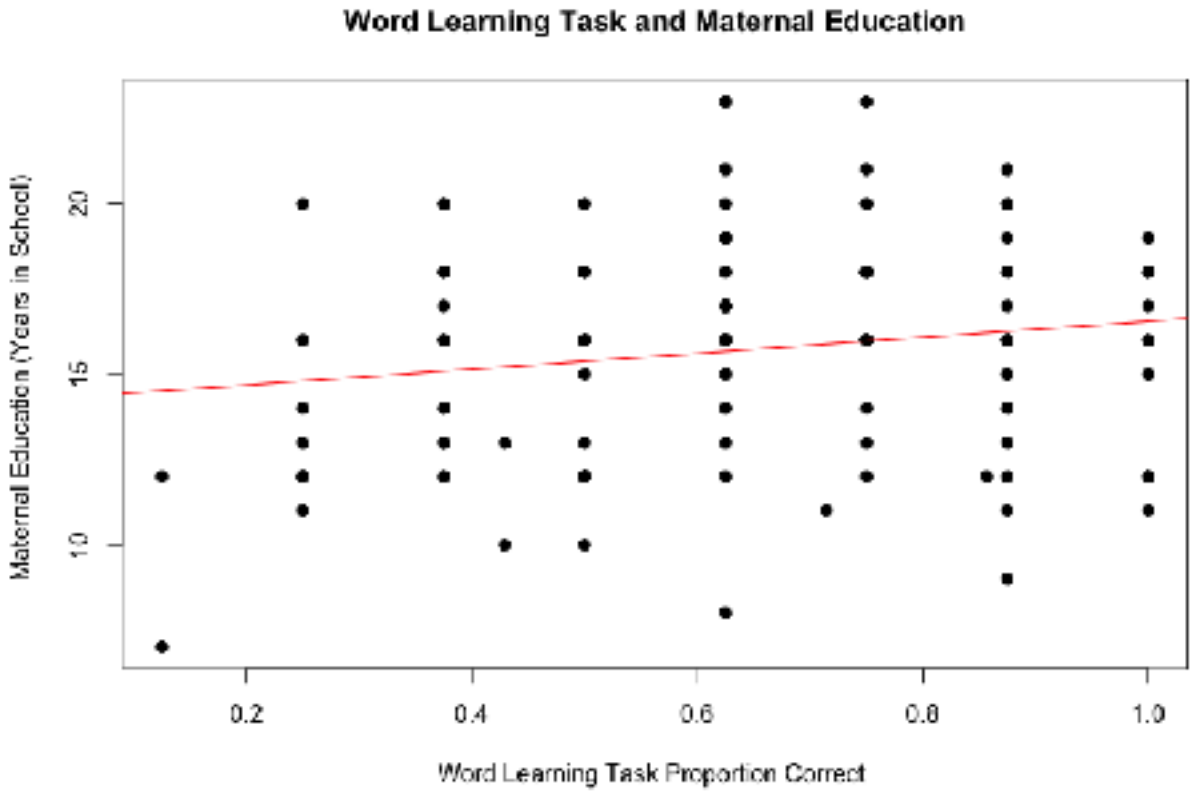
for the latter four trials (in which both eye gaze and pointing were available cues), $r(138) = 0.19$, $p = 0.03$. For the first four trials (in which only eye gaze was available as a cue), the correlation between the word learning task and maternal education was not significant, $r(138) = 0.11$, $p = 0.20$.

Table 2. Correlation results between study variables.

Variable	**1.Maternal Education**	**2. PPVT**	**3.Word Learning Task**	**4.Word Learning Task**	**5.Word Learning Task**
			All Trials	**First 4 Trials**	**Second 4 Trials**
1. Maternal Education					
2. PPVT	0.41**				
3. All Trials	0.17*	0.08			
4. First 4 Trials	0.11	0.11	0.81***		
5. Second 4 Trials	0.19*	0.03	0.73***	0.21**	
6. MEFS	0.28***	0.38***	0.14	0.04	0.22*

Note: simple correlation coefficients are shown. *** p < .001, ** p < .01, * p < .05

Figure 1. Scatterplot of performance on the word learning task and maternal education (years in school)



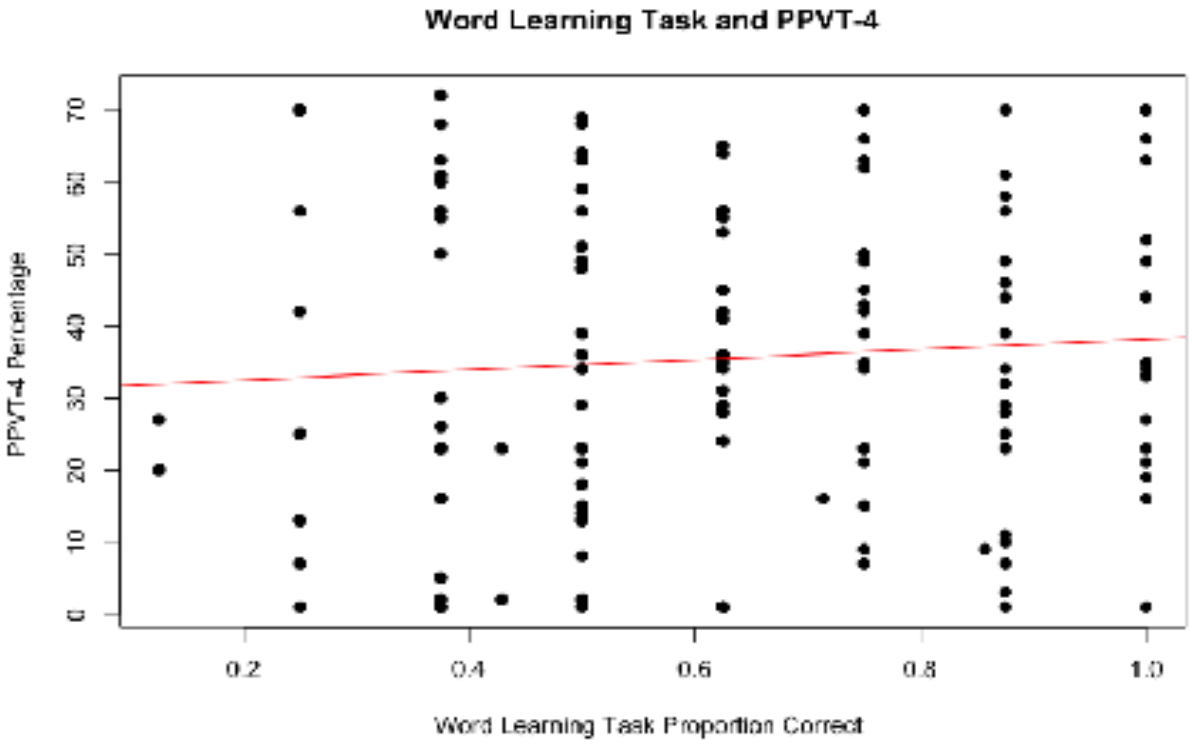
In order to explore this relationship more carefully, we applied a median split to the age distribution and considered older and younger children in the sample separately. This allowed us to determine whether the relationship between maternal education and word learning performance differs in strength across specific developmental windows. Within the younger group (< 2.96 years), the correlation between socioeconomic status and overall performance on the word learning task was trending toward significance, $r(65) = 0.20$, $p = 0.09$. Within the older group (>=2.96-years-old), however, this relationship did not approach significance, $r(71) = 0.15$, $p = 0.21$. The correlation for the younger group grew much stronger when only the latter four trials (in which both eye gaze and pointing were available cues) were considered, $r\,(65) = 0.26$, p

= 0.03, and weakened considerably when only the first four trials (in which only eye gaze was available as a cue) were considered, $r(65) = 0.07$, $p = 0.58$. For the older group, maternal education and task remained uncorrelated regardless of which subset of trials was considered, *p*s >.25.

3.1. ANCILLARY ANALYSES

In order to confirm whether our data replicated fundamental findings in the literature, we examined bivariate correlations between other key measures. As expected, age-standardized PPVT-4 scores were significantly correlated with maternal education, $r(155) = 0.41$, $p < 0.01$. However, PPVT-4 scores were not significantly correlated with performance on the word learning task, regardless of whether all trials were considered together or for gaze and point trials separately, $r(138)$ ranged from .03 to .11, all *p*s > .19. See Figure 2 for a scatterplot of relevant data. Because this lack of association was unexpected in light of previous research, we followed up with further exploratory analyses, focusing on additional subsets of the data. However, none of these revealed the expected association. Specifically, no association was evident for either high or low SES children when examined separately.

Figure 2: Participant's performance on the PPVT-4 and the word learning task



Finally, in order to determine whether the observed association between SES and word learning might be partially accounted for by shared variance in executive functioning, we conducted a regression analysis including MEFS scores as a control factor. Participant's age was not included as a control variable because it did not correlate with the other key predictor (socioeconomic status), $r(139) = 0.04$, $p = 0.64$. Overall, the model approached significance $R^2 = 0.04$, $F(2,137) = 2.87$, $p = .06$, with neither MEFS nor maternal education accounting for a significant amount of variance in word learning performance, $\beta = .00$, $p = 0.23$ and, $\beta = .01$, $p = .09$, respectively.

4. DISCUSSION

To review, our study examined individual differences in children's ability to accurately interpret an adult's eye gaze and point for word learning purposes. Specifically, we considered whether developmental differences in using eye gaze and pointing to learn novel words were related to a child's socioeconomic status. We predicted that development of eye gaze and point following skills would be slower for low socioeconomic status children than their high socioeconomic status peers. Further, we predicted that higher socioeconomic status would be associated with more reliable use of these cues.

4.1. EXAMINING THE RELATIONSHIP BETWEEN MATERNAL EDUCATION AND WORD LEARNING SKILLS

Results from our study indicate that socioeconomic status is positively associated with performance on a word learning task aimed at measuring children's ability to follow eye gaze and point following to identify referents. These results therefore both partially align with previous research and support our expectation that a low SES background is associated with weaker abilities to use eye gaze and point following cues for word learning purposes.

An additional interpretation is that this outcome is a reflection of the cultural derivation of the pointing gesture. Using a point to identify possible referents in a child's environment may very well be specific to an individual's culturally-specific reinforcement (Kita, 2013). It should be noted that we did not measure parents' use of and response to the pointing gesture in their home environment so we are unable to assess whether this cultural difference correlates with socioeconomic status. However, Hirsh-Pasek (2015) found that the quality of joint attention

episodes varied depending on maternal education and, further, that joint attention quality predicted a child's expressive language one year later (but see Hoff, 2003, who found that variability in number of utterances used in joint attention episodes did not predict vocabulary). It logically follows that, in households where caregivers are neither using nor responding positively and/or consistently to pointing gestures, it becomes a much less important cue for word learning purposes. As such, a child coming from this household may continue to rely on eye gaze as a cue to the referent in our word learning task, failing to utilize the additional pointing cue. In some cases, the child may focus on the finger when a point is presented simply because it is a novel occurrence and they do not realize its meaning. Children who have been more consistently exposed to the pointing gesture would have a significantly easier time identifying the appropriate referent in our word learning task than those who have not. Their experiences engaging in high quality joint attention episodes in which a point is involved could potentially aid in the development of this skill.

Interestingly, we also found that the general correlation we observed between maternal education and word learning performance held for the younger half, but not the older half of our sample. Combined, these results provide support for the notion that a child's socioeconomic status background may have a larger effect on word learning when they are younger. There are various possibilities for why this might be the case.

The first relates to our central argument in that, generally, children coming from low-SES households are simply not engaging in joint attention episodes at the same prevalence as their high-SES peers, thus decreasing the number of times they have used or responded to gaze and

point following. As both groups of children get older, increased exposure to communication partners outside of their immediate household would possibly provide a greater opportunity for them to acquire the word learning skills. Older children from low SES households could therefore develop the eye gaze and point following skills to the point that their performance aligns with the children from high SES backgrounds.

Another possibility for why the relationship between maternal education and word learning performance weakens for the older children could be that eye gaze and point following is fully mastered for all children by the time they reach their third birthday. However, the below ceiling performance of all children in our sample indicates that this is not the case. It would be fruitful for future studies to take a more detailed look into this relationship between maternal education, word learning, and age to identify more precisely when this shift occurs in order to better identify possible reasons why.

Finally, it is possible that point and gaze following are particularly important for younger children during the initial stages of vocabulary development when the majority of words acquired are concrete nouns. As a child begins to add words to their repertoire, concrete nouns inevitably give way to more abstract nouns, as well as verbs and other word types which require the ability to use additional cues from communication partners and the environment. Perhaps the younger children coming from low SES households who have not acquired the ability to use gaze and point following for word learning purposes are able to use the additional cues, in concert with immature/emerging gaze and point following skills, to effectively learn new words without so much reliance on gaze and point following.

4.2. THE RELATIONSHIP BETWEEN THE WORD LEARNING TASK AND VOCABULARY ACQUISITION

Surprisingly, performance on the word learning task was not significantly correlated with PPVT-4 scores, a measure of a child's acquired vocabulary. This may be interpreted to suggest that eye gaze and point following are not important skills for real world acquisition of vocabulary. However, this conclusion would be at odds with a wealth of existing empirical data documenting relationships between joint attention skills and early language acquisition (Brooks & Meltzoff, 2008; Colonnesi, Stams, Koster, & Noom, 2010). What might account for this disparity?

One possibility is that acquiring eye gaze and point following skills is a better predictor of vocabulary acquisition at a later date. That is, perhaps the emerging word learning skills children are using, in this case, gaze and point following, are not immediately affecting real world vocabulary development, but are having a longer-term impact. Indeed, previous studies have largely indicated that children's joint attention skills predicts *future* vocabulary (Brooks & Meltzoff, 2008; Colonnesi, Stams, Koster, & Noom, 2010). So, for the children who are just starting to use this word learning skill, we might see a correlation with vocabulary at a later date (rather than contemporaneously, as tested here). To test this idea, our lab is currently in the process of running follow-up sessions with participants, 6-months to one year from their first session, which will allow us to asses longer-term impact of developing word learning skills on vocabulary.

Another possible reason why we did not find a correlation between our word learning task and children's vocabulary acquisition is that we tested substantially older children than those included in existing studies. The average age of the children in our sample was 35-months-old while than those tested previously ranged from 3- to 18-months-old. It is entirely possible that eye gaze and point following is particularly important for children when they are first learning words but becomes less so as children develop and mature in using other word learning skills: As children's repertoire of word learning skills expands, it follows that they will begin to use the full range of skills available to them, adapting to the context accordingly. So, a child may be faced with situations in which they have multiple cues at their disposal that they can choose between to learn new words. This notion aligns with an Emergentist Coalition Model (ECM) of word learning, particularly the second tenet, stating that children's ability to use word learning cues changes over time, as does the relative weight placed on these cues (Hollich et. al., 2000).

A final possibility for why we did not find a correlation between our word learning task and children's vocabulary acquisition could be that the types of words tested in the PPVT-4 are not well aligned with those for which gaze and pointing skills are most useful. While the targeted word type in the PPVT-4 is largely concrete nouns, more abstract nouns, verbs, and other word types also appear on the test. In this case, it logically follows that the correlation between the gaze and point following task and the PPVT-4 would be weaker.

4.3. POTENTIAL LIMITATIONS

A potential limitation of our study is the fact that we only have a single measurement of each child's ability to use eye gaze and point following for word learning purposes. This data

point was taken at an unknown time relative to the point of true acquisition. As such, our findings reflect a less precise measurement of the age at which an individual acquires the ability to effectively use gaze and point following skill than a longitudinal design would reveal. Indeed, a longitudinal design would aid in providing additional insight into the difference in the developmental timeline of these skills between high and low SES children.

4.4. FUTURE DIRECTIONS

One particularly valuable contribution of this study is the development of a measure that can be used to specify when children acquire the ability to use eye gaze and point following to learn new words. Despite the fact that we did not find a correlation between the PPVT-4 and our word learning task, it would still be valuable to consider predictive relations between the two in future studies, that is, whether a child's performance on the word learning task could be used to predict their future vocabulary development. Our lab is currently exploring this possibility by inviting participants to a follow-up session in which they complete form B of the PPVT-4, 6- to 12- months after they completed form A. During the follow-up session, the children will also complete the Test of Early Preschool Literacy (TOPEL), a standardized test assessing a child's print and oral vocabulary, as well as phonological awareness.

This study also provides important insights that might be helpful in developing early interventions targeting vocabulary development. Indeed, children who have yet to acquire pivotal word learning mechanisms (i.e., eye gaze and point) could perhaps benefit from vocabulary interventions that focus on teaching them how to learn new words. This would represent a significant departure from traditional vocabulary interventions that have largely focused on

directly teaching children new words through various evidence based methods. These intervention programs have had some success in enhancing language development and early literacy skills of at-risk preschoolers (e.g., Puma et al., 2010; Wasik & Bond, 2001). Yet, even when these interventions are employed, the disparities between low and high SES children's vocabulary development remain. In their review of various approaches of vocabulary instruction for at-risk children, Christ and Wang (2011) highlighted that even if children from low socioeconomic status backgrounds learn many new words per year from an intervention, their peers from higher socioeconomic status backgrounds will also likely make the same vocabulary gains. Thus, though existing interventions might help to keep the gap from increasing, there is no way the lower SES children can catch up, and closing the vocabulary gap will be impossible. Despite the best efforts of caregivers, teachers, community members, and researchers to change the trajectory of at-risk children's vocabulary development, there is ample room for improvement.

It is important to acknowledge that a vocabulary intervention would only be required and effective if eye gaze and point following is indeed an important word learning mechanism for real world vocabulary acquisition. Despite our findings showing a lack of relationship between PPVT-4 scores and performance on the word learning task, we continue to believe that existing literature has provided ample evidence of the importance of both gaze and point following skills playing a role in a child's ability to learn new words. As such, we believe that an intervention focusing on teaching children how to use eye gaze and point following to learn new words could be a useful approach. Importantly, this approach could potentially help overcome the inherent limitations of prior intervention efforts by facilitating the generalization of vocabulary gains

beyond the specific words taught. Indeed, a primary goal would be to ensure that children have the tools they need to acquire new vocabulary seamlessly throughout the course of their daily lives inside and outside of the classroom.

If, as predicted, gaze and point can be explicitly taught, perhaps other word learning mechanisms seemingly supported by episodes of joint attention could be as well. Future interventions could therefore target other word learning strategies, such as the mutual exclusivity assumption. Recall, for example that research has suggested children's reliance on Mutual Exclusivity likely emerges from their experience using other socio-pragmatic cues to unambiguously identify the referents of novel words and abstracting from that experience the expectation that new words refer to things for which they don't already know a name (Diesendruck & Markson, 2001; Saylor, Sabbagh, & Baldwin, 2002). A potential future intervention could therefore focus on providing at-risk children exposure to more practice engaging in joint attention interactions, with multiple naming episodes for both novel and familiar items in various learning contexts. Perhaps this type of intervention could help in the development of skills beyond those specifically tested here (i.e., mutual exclusivity). As is the goal of the proposed gaze and point intervention, this approach to word-learning development could lead to generalization of vocabulary gains beyond the specific number of words learned.

Finally, we believe that an intervention could be useful for populations beyond socioeconomically at-risk children. Special populations struggling with language acquisition (i.e., children with learning disabilities, language delay or disorder, Down syndrome, autism, etc.) could also potentially benefit from our approach to intervention. Indeed, children who are

on the autism spectrum may particularly benefit from this approach due to its focus on teaching skills that are related to joint attention, an area in which autistic children's difficulty has been well documented (Leekman et al., 2000; Mundy, 1995; Osterling & Dawson, 1994). Future research could therefore target these populations to evaluate whether providing explicit instruction on how to learn new words would have the same impact as it does on the typically developing, at risk-children we have included in this study.

5. CONCLUSION

In conclusion, scientific evidence suggests that children from more advantaged homes have more advanced language skills than children of the same age from less advantaged homes. The evidence presented here supports the idea that a child's ability to use eye gaze and point following for word learning purposes is associated with their socioeconomic background and related experience with joint attention episodes. Indeed, socioeconomic status is positively associated with performance on a word learning task that measures children's ability to follow eye gaze and points to identify referents. Indeed, children from high socioeconomic status backgrounds used the gaze and point following skills more reliably than their peers from lower socioeconomic backgrounds. These results offer insight into a pivotal word learning mechanism that could help to at least partially explain why children from low socioeconomic backgrounds have, on average, lower vocabularies and are unable to catch up to their peers. Future research should therefore examine interventions targeting specific word learning skills, such as gaze and point following, to aid children's vocabulary development.

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